SPOOR AND FISHER

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| 71 | HSM HOLOGRAPHIC SYSTEMS MUNCHEN GMBH |

FULL NAME(S) OF INVENTOR(S)

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TITLE OF INVENTION

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| 54 | A METHOD AND AN APPARATUS FOR FABRICATING A SURFACE STRUCTURE, PARTICULARLY A HOLOGRAPHIC SURFACE STRUCTURE, ON A SUBSTRATE |

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If no classification is finished, Form P.9 should accompany this form.

## Abstract

A method serves the fabrication of a surface structure, in particular of a holographic surface structure, on a substrate. To allow in a simple manner an individualised fabrication of the surface structure, the substrate (4) is coated with a radiation-curable substance, in particular a radiation-curable monomer (5). An embossing pattern is introduced into the coating, for example by a cylinder (10). The embossing pattern is cured with a modulated irradiation beam (1a, 1b) (Fig.1).

The invention relates to a method for fabricating a surface structure, particularly a holographic surface structure, on a substrate and to an apparatus for the performance of such a method.

The surface structure to be fabricated is generally a relief structure. A given or defined surface structure or relief structure has to be applied to the substrate. The substrate can then be used in particular as a die (relief master) for embossing holography.

The object of the invention is to provide a method and an apparatus of the type described above with which an individualised fabrication of a surface structure, particularly of a holographic surface structure, is made possible in a simple manner.

In accordance with a first proposal, this object is addressed in a method of the type described above by the substrate being coated with a radiation-curable substance, in particular with a radiation-curable monomer, by an embossing pattern being introduced into the coating and by the embossing pattern being cured with a modulated irradiation beam. The radiation-curable substance is preferably a fluid substance. This substance can preferably be cured by means of electromagnetic rays, for example UV light. A regular embossing pattern can be applied. The radiation-

curable substance is cured by the irradiation beam in those regions which are reached by at least one modulated irradiation beam. Naturally, the irradiation beam(s) must be suitable to cure the radiation-curable substance.

The embossing pattern is preferably applied by a cylinder. However, it may also be applied by a plane element moved intermittently. The cylinder can possess a regular relief structure on its surface.

The modulated radiation can be performed by means of a scanner, in particular by means of a line scanner. This is also particularly of advantage if the embossing pattern is applied by means of a cylinder. The line of the line scanner then preferably runs parallel to a circumferential line of the embossing cylinder or at a right-angle to the direction of forward movement of the scanner.

A further advantageous improvement is characterised by the fact that the irradiation is effected by an LCD. The LCD can be controlled by a PC or other computer so that the surface structure regions to be cured individually can be programmed very quickly and simply.

The method can be repeated once or several times. In this way, it is possible to fabricate one after the other on a substrate several surface structures which may differ from one another as required and which can be positioned next to one another or which may also overlap.

For example, the non-cured substance or the non-cured monomer is washed out after the irradiation or the curing.

The invention also provides for an apparatus for the fabrication of a surface structure, in particular of a holographic surface structure, on a substrate comprising a cylinder over which a substrate coated with a radiation-curable substance, in particular with a radiation-curable monomer, can be guided and an irradiation apparatus to irradiate the coated substrate with a modulated irradiation beam.

Preferably, a coating apparatus for the coating of the substrate with a radiation-curable substance, in particular a radiation-curable monomer, is connected in series prior to the cylinder.

Preferably, the irradiation apparatus is located outside the cylinder. In this case, the substrate is translucent for the rays of the irradiation apparatus. The irradiation apparatus can, however, also be located within the cylinder. In this case, the surface of the cylinder is transparent for the irradiation beams.

Preferably, the irradiation apparatus comprises a light modulator, for example a scanner, in particular a line scanner, and/or an LCD.

Preferably, several apparatuses are located in series one after the other. The substrate passes through these apparatuses one after the other. In this way, several surface structures, which may differ as required, can be fabricated one after the other on the substrate which surface structures are then located next to one another and/or overlapping on the substrate.

For example, a washing unit is connected subsequent to the cylinder to wash out the non-cured substance or the non-cured monomer.

The object forming the subject of the invention is addressed in a method of the type described above in accordance with a second proposal for which independent protection is claimed by a radiation-curable substance, in particular a radiation-curable monomer, being applied to the substrate in accordance with the surface structure to be fabricated and the substance being irradiated with an irradiation beam. In this case, therefore, the radiation-curable substance is not applied to the whole surface region of the substrate, but only to that region where the surface structure should later be located. There, the substance is then irradiated and thus cured. One advantage of this procedure consists of a washing out of any liquid substance in those areas where no surface structure should be located no longer being necessary.

The two methods in accordance with the invention differ by means of the following: in accordance with the method first given, the radiation-curable substance is first applied to the whole substrate or, however, at least to regions of the substrate which are greater than that region on which the surface structure should later be located. The surface structure is then manufactured in that only those regions on which the surface structure should later appear are irradiated with an irradiation beam. In contrast, in the second method, the radiation-curable substance is from the beginning only applied to the substrate where the surface structure should later appear. Here, the curing beam does not need to be modulated (as long as no additional hologram is irradiated).

The radiation-curable substance or the radiation-curable monomer can be applied to the substrate by specific application, for example by spraying or imprinting or by another method. In accordance with another advantageous improvement, the radiation-curable substance or the radiation-curable monomer can be applied to a cylinder with surface relief and subsequent to curing by irradiation be applied to the substrate from this. In this case, the radiation-curable substance or the radiation-curable monomer is,

for example, applied individually to the embossing cylinder by means of ink-jet nozzles. For the curing, only uniform, unmodulated radiation is required.

The method can be repeated once or several times to apply different surface structures to the substrate as required and this to regions of the substrate which are next to one another or which overlap.

The invention further provides for an apparatus for fabricating a surface structure, in particular a holographic surface structure, on a substrate comprising an application apparatus to apply a radiation-curable substance, in particular a radiation-curable monomer, to the substrate in accordance with the surface structure to be fabricated and an irradiation apparatus to irradiate the substance.

The apparatus preferably comprises a cylinder. The application apparatus comprises, for example, ink-jet nozzles to apply the radiation-curable substance or the radiation-curable monomer to the substrate and/or to the cylinder. It is advantageous if several apparatuses are connected in series in order to fabricated different surface structures to the substrate as required, and this to regions of the substrate which are next to one another and/or which overlap.

By means of the invention, in particular holographic surface structures can be fabricated. However, it is also possible to fabricate other surface structures, for example, optical gratings. The surface structures are manufactured in the form of casting or moulding.

Embodiments of the invention are described in detail below by means of the enclosed drawing in which

Fig. 1 shows an apparatus for fabricating a surface structure on a substrate with a cylinder in a side view;

Fig. 2 shows the apparatus shown in Fig. 1 with, in addition, a coating apparatus and a line scanner in a perspective view;

Fig. 3 shows a modification of the apparatus shown in Fig. 2 with an LCD

Fig. 4 shows a washing unit in a side view;

Fig. 5 shows two apparatuses from Fig.2 connected in series one after the other;

Fig. 6 shows an apparatus for fabricating a surface structure on a substrate with ink-jet nozzles in a perspective view; and

Fig. 7 shows an apparatus for fabricating a surface structure on a substrate with ink-jet nozzles to apply the surface structure to a cylinder in a perspective view.

In the apparatus shown in schematic form in Fig. 1, a foil 4, which is coated with a liquid, radiation-curable monomer 5, is supplied to a rotating cylinder 10. The cylinder 10 comprises a cylindrical surface (cylinder wall) 3 to whose outside a surface structure 2 is applied. It is, for example, a hologram surface structure. The foil 4 is first guided round a first guide roller 7. It then comes into contact with the surface structure 2 in such a way that the liquid, radiation-curable monomer 5 is positioned on the side of the foil 4 facing the surface structure 2. The feed rate 11 of the foil 4 is

precisely the same as the circumferential speed of the cylinder wall 3. Then, the foil is deflected by a further guide roller 7' and transported away.

While the foil 4 is in contact with the surface structure 2, the embossing pattern is applied to the monomer coating 5 of the foil 4, that is the (negative) embossing pattern of the surface structure 2. This embossing pattern is irradiated with a modulated irradiation beam 1a and/or 1b. The irradiation can be effected by a modulated irradiation beam 1a from the inside, that is from the interior of the cylinder. In this case, the cylinder wall 3 must be translucent. However, the irradiation can also be effected by means of a modulated irradiation beam 1b from the outside or the inside. In the case of irradiation from the outside, the foil 4 should be translucent; in the event of irradiation from the inside, the embossing cylinder be translucent in order to allow an irradiation and curing of the monomer 5.

The irradiation beam 1a and/or 1b is modulated in such a way that only certain predetermined regions of the embossing pattern are irradiated with light. These regions are shown in black in Fig. 1. In these regions, the monomer 5 is cured. In this way, the predetermined surface structure is formed on the foil with monomer 6 cured by means of irradiation. Liquid monomer 5 can still be found between the cured regions.

In Fig. 2, the coating apparatus positioned prior to the cylinder is shown which coating apparatus comprises a tank 8 filled with liquid monomer, a lower coating roller 9 and an upper coating roller 9'. The lower coating roller 9 dips into the liquid monomer in the tank 8. It rotates counter-clockwise and is in contact with the upper coating roller 9' which rotates clockwise and whose circumferential speed is the same as the transportation rate 11 of the film 4.

In the embodiment of Fig. 2, irradiation is effected with the modulated irradiation beam 1 by means of a line scanner 2 which consists of a rotating polygon mirror and which is irradiated by the beam source 3 with modulation capability. The line of the line scanner 2 runs parallel to a circumferential line of the cylinder 10. In this way, regions 14 with cured monomer are applied to the foil 4.

The version shown in Fig. 3 differs from that in Fig. 2 in that the line scanner has been replaced by an irradiation apparatus with an LCD 23 which irradiation apparatus is irradiated by an expanded irradiation beam 1 through a lens system 22. The predetermined surface structure is fabricated on the LCD 23. The expanded irradiation beam 1 is guided onto the LCD 23 by the lens system 22 and modulated there. The LCD is located above the cylinder 10 parallel and at a distance to one of its circumferential lines.

In Fig. 4, a washing unit for the non-irradiated monomer is shown. It consists of a washing drum 34 which rotates in a container with washing solution 33. The foil 31, on which regions with cured monomer and with liquid monomer are located, is led via a first rubber scraper 32 to a guide roller 35. From there, the foil 31 comes to the outside circumference of the washing drum 34 in such a way that the monomer regions are located on the outside circumference. In the washing solution 33, the liquid monomer is then removed from the foil 1. The foil 31 washed in this way is then guided through a rubber roller 36 after one wrap around the washing drum 34. By means of the rubber roller 36, which is in contact with the washing drum 34, any solvent still adhering to the foil 31 is simultaneously squeezed off.

The foil 37 with cured monomer is subsequently led to further rubber scrapers 32 on both sides of the foil 37 which scrape off any residues of monomer and/or solvent. Following on from these are hot-air nozzles 38 on both sides of the foil 31 which blow off any monomer and/or solvent residues still remaining.

Fig. 5 shows two apparatuses of the type shown in Fig. 2 connected one after the other. Identical parts are identified by the same symbols so that they do not need to be described again. By means of the first inscription beam 1, a first surface structure 14 is applied to the foil 4. The second inscription beam 1' applies a second surface structure 14' to the film 4. In the embodiment of Fig. 5, the regions 14 and 14' are next to each other. However, they may also overlap in full or in part.

In Figs. 6 and 7, embodiments in accordance with the second solution in accordance with the invention are shown. In the embodiment of Fig. 6, a radiation-curable monomer is applied in accordance with the surface structure 44 to the foil 4 by ink-jet nozzles 41. It is then found on the foil 4 as a sprayed monomer 42 in the pre-determined surface structure. This pre-determined surface structure is fabricated by means of a corresponding control of the ink-jet nozzles 41. While passing the cylinder 10, the foil 4 is irradiated with the expanded irradiation beam 43. In this way, the monomer located at the pre-determined areas is cured. On the regions 44, cured monomer is then found on the foil 4.

Fig. 7 shows a modified embodiment in which the ink-jet nozzles 41 do not apply the monomer directly to the foil 4, but first to the cylinder 10 provided with a regular surface structure or relief structure. The ink-jet nozzles 41 are located below the cylinder. After one rotation of the cylinder 10, its surface is irradiated by an expanded irradiation beam 52. The ink-jet nozzles 41 have applied the monomer to the cylinder 10 only on those pre-determined areas on which the surface structure 57 should be fabricated. There, the monomer is then cured by the expanded irradiation beam 52. Subsequently, it is transferred to the foil 4.

The foil 4 is first deflected downwards by a guide roller 55 which is located above the cylinder 10. It is brought into contact with the surface of the cylinder 10 by a pressure roller 56. The foil 4 is then guided away by a further guide roller 55.

As in the embodiments of Figs. 6 and 7, the monomer is only applied to the pre-determined areas on which the surface structure should be fabricated, no washing unit is required.

By means of the invention, the copying capability and the imitation of security holograms is made substantially more difficult. It is possible to fabricate microstructures which make counterfeiting difficult in a simple manner. These microstructures can be fabricated by means of an individualisation such as a numbering, a bar code, personal images (for I.D.s, etc.) or similar.

By means of the invention, a method and an apparatus are provided for the individualised transfer of surface structures onto translucent and non-translucent substrates. No expensive holographic equipment is needed. In particular, among other things, the irradiation can be effected with a non-coherent light source. The individualisation of the information to be transferred can be performed with very low effort and by the utilisation of existing technologies such as LCD displays (projectors), modulated lasers (laser printers), ink-jet monomer application (ink-jet printers), electron beam scanners (welding, drilling), electro-mechanically adjustable masks, thermal transfer technology (printers, facsimile machines) and/or electrostatic discharging with laser scanners (laser printers).

By means of a combination or overlapping of different structures, complex structures can be manufactured simply in one workstep. Even structures with a large area can be manufactured with minimum equipment effort. The invention allows a simple and direct preparation of relief masters for embossing holography with and without the use of coherent lasers and holographic equipment. By mixing in different dyestuffs, fluorescent dyestuffs, reversible thermal dyestuffs and/or ferro-magnetic substances in micro-encapsulated form (or also directly) to the monomer, imitation or counterfeiting is made more difficult. By means of a multiple application onto overlapping regions, elevations or relief structures can be fabricated on the substrate.

In accordance with the first solution in accordance with the invention, the substrate is coated with a radiation-curable substance, in particular with a radiation-curable monomer. This process step can, however, be omitted if a pre-coated substrate is used for the process. In this case, the embossing pattern is applied to the coating of the pre-coated substrate and this embossing pattern is then irradiated with the modulated or unmodulated irradiation beam.

In the multiple application of monomer shown in Fig. 5, elevations of the cured monomer layer can be fabricated if the regions which are coated in each case overlap. These elevations can be tangible or measurable by means of which an additional authenticity feature is created. In addition, it is possible to provide the first cylinder 10 with a first structure and the second cylinder 10' with a second or multiple structures. The structures can correspond to a first and a second colour.

## CLAIMS

1. A method for the fabrication of a surface structure on a substrate, characterised in that the substrate is coated with a radiation-curable substance, an embossing pattern is introduced into the coating and the embossing pattern is cured with a modulated irradiation beam.
2. A method in accordance with claim 1 wherein the embossing pattern is applied by a cylinder.
3. A method in accordance with either of claims 1 or 2 wherein the irradiation is effected from the side of the substrate facing away from the coating.
4. A method in accordance with any one of the preceding claims wherein the irradiation is effected by a scanner.
5. A method in accordance with claim 4, wherein the scanner is a line scanner.
6. A method in accordance with any one of the preceding claims wherein the irradiation is effected by an LCD.
7. A method in accordance with any one of the preceding claims wherein the process is repeated once or several times.
8. A method in accordance with any one of the preceding claims wherein the non-cured substance or the non-cured monomer is washed out.
9. An apparatus for fabricating a surface structure on a substrate, comprising a cylinder over which a substrate coated with a radiation-curable substance can be guided and an irradiation apparatus for the irradiation of the coated substrate with a modulated irradiation beam.

10. An apparatus in accordance with claim 9 wherein a coating apparatus for the coating of the substrate with a radiation-curable substance is connected in series prior to the cylinder.

11. An apparatus in accordance with either of claims 9 or 10 wherein the irradiation apparatus is located outside the cylinder.

12. An apparatus in accordance with either of claims 9 or 10 wherein the irradiation apparatus is located inside the cylinder.

13. An apparatus in accordance with any one of claims 9 to 12 wherein the irradiation apparatus comprises a scanner.

14. An apparatus in accordance with claim 13, wherein the scanner is a line scanner.

15. An apparatus in accordance with any one of claims 9 to 14 wherein the irradiation apparatus comprises an LCD.

16. An apparatus in accordance with any one of claims 9 to 15 wherein several apparatuses are connected in series one after the other.

17. An apparatus in accordance with any one of claims 9 to 16 wherein a washing unit to wash out the non-cured substance or the non-cured monomer is connected in series after the cylinder.

18. A method for fabricating a surface structure on a substrate

characterised in that a radiation-curable substance is applied to the substrate in accordance with the surface structure to be fabricated and in that the substance is irradiated with a radiation beam.

19. A method in accordance with claim 18 wherein the radiation-curable substance is applied to the substrate by specific application.

20. A method in accordance with claim 19, wherein the specific application is spraying.

21. A method in accordance with claim 18 wherein the radiation-curable substance is applied to a cylinder with a surface relief and applied from there to the substrate after curing by irradiation.

22. A method in accordance with any one of claims 18 to 21 wherein the process is repeated once or several times.

23. An apparatus for fabricating a surface structure on a substrate comprising an application apparatus for the application of a radiation-curable substance to the substrate in accordance with the surface structure to be fabricated and an irradiation apparatus to irradiate the substance.

24. An apparatus in accordance with claim 23 characterised by a cylinder.

25. An apparatus in accordance with either of claims 23 or 24 wherein the application apparatus comprises ink-jet nozzles for the application of the radiation-curable substance to the substrate and/or the cylinder.

26. An apparatus in accordance with any one of claims 23 to 25 wherein several apparatuses are connected in series one after the other.

27. A method in accordance with claim 1 or claim 18, wherein the surface structure is a holographic surface structure.

28. A method in accordance with claim 1 or claim 18, wherein the radiation-curable substance is a radiation-curable monomer.

29. An apparatus in accordance with claim 9 or claim 23, wherein the surface structure is a holographic surface structure.

30. An apparatus in accordance with claim 9 or claim 23, wherein the radiation-curable substance is a radiation-curable monomer.

31. A method substantially as herein described with reference to any one or more of Figures 1 to 7 of the accompanying drawings.

32. An apparatus substantially as herein described with reference to any one or more of Figures 1 to 7 of the accompanying drawings.

DATED THIS 3RD DAY OF AUGUST 1998

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APPLICANTS PATENT ATTORNEYS

FIG. 1

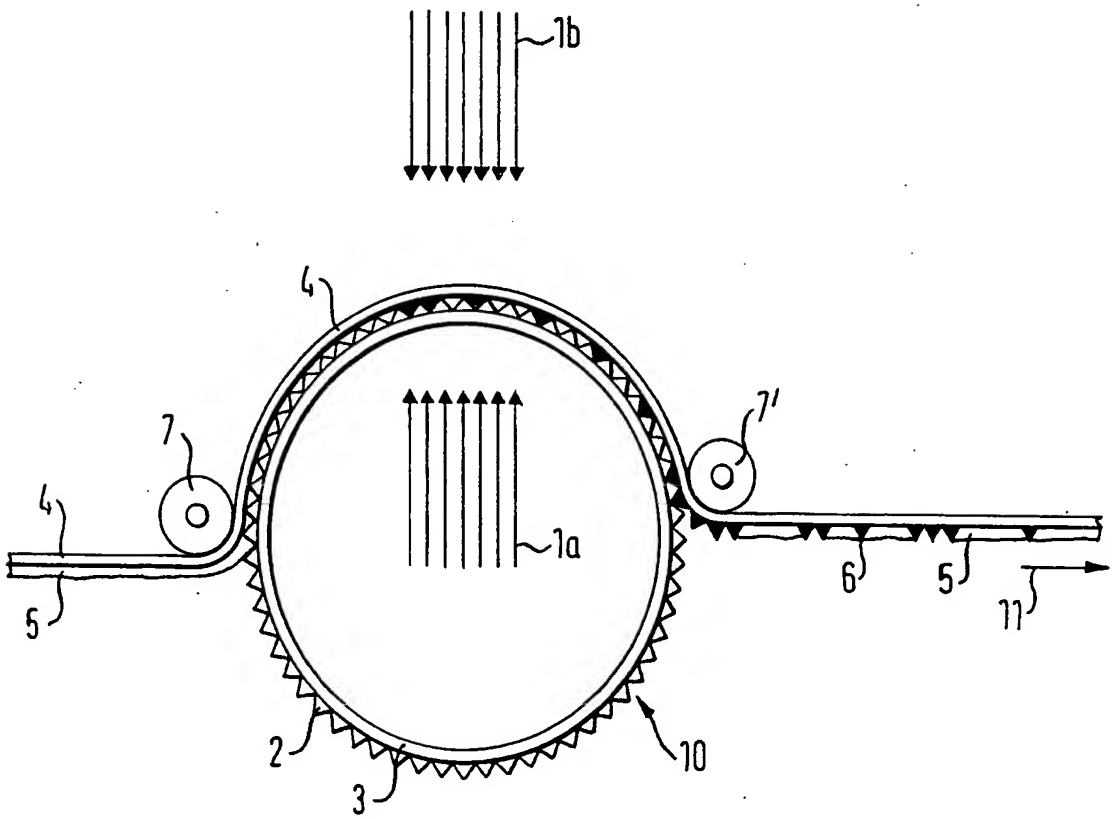


FIG. 2

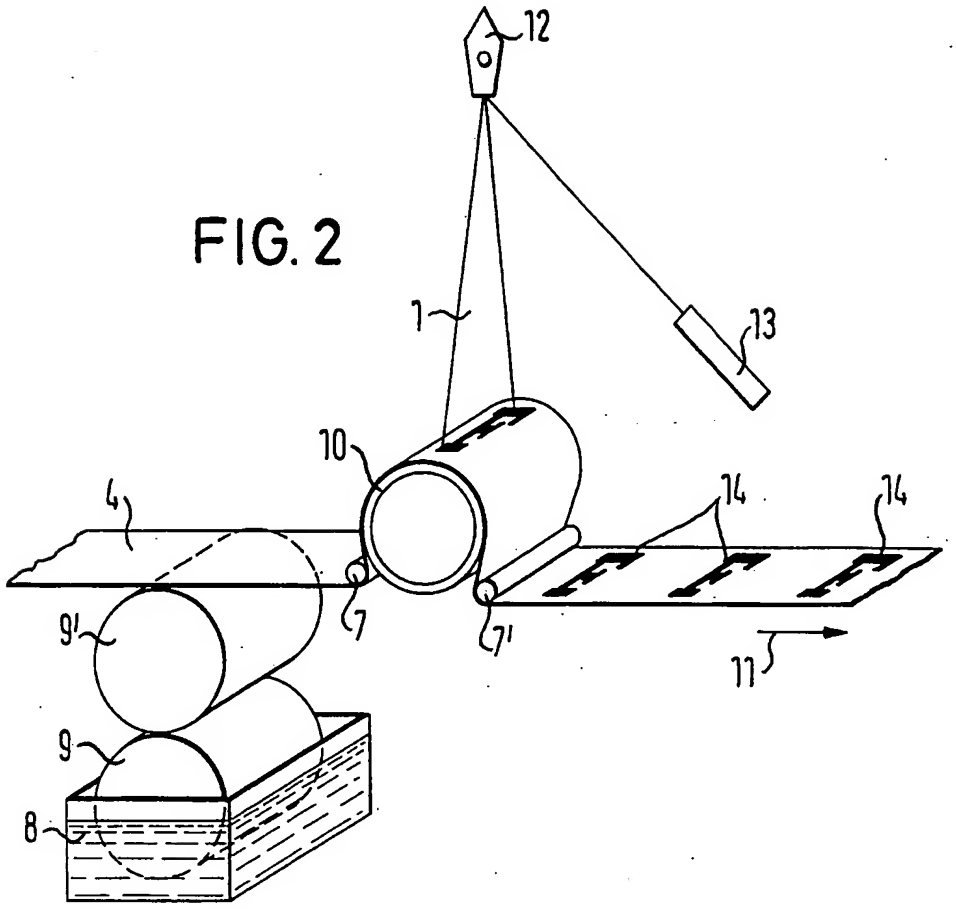



FIG. 3

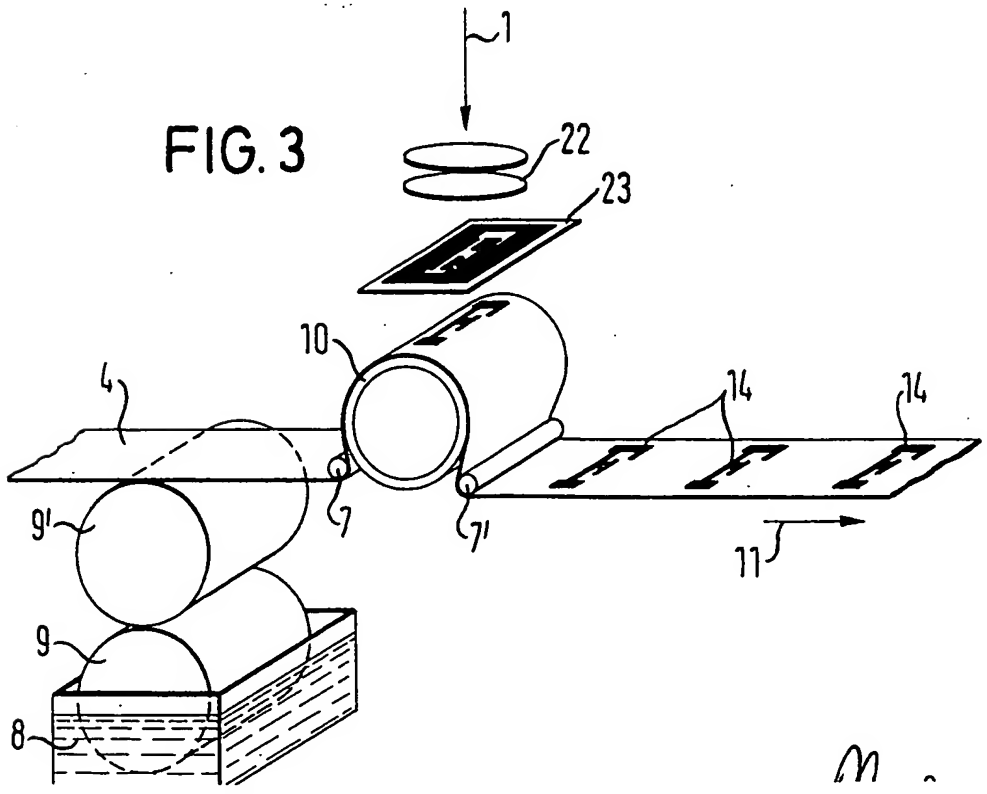
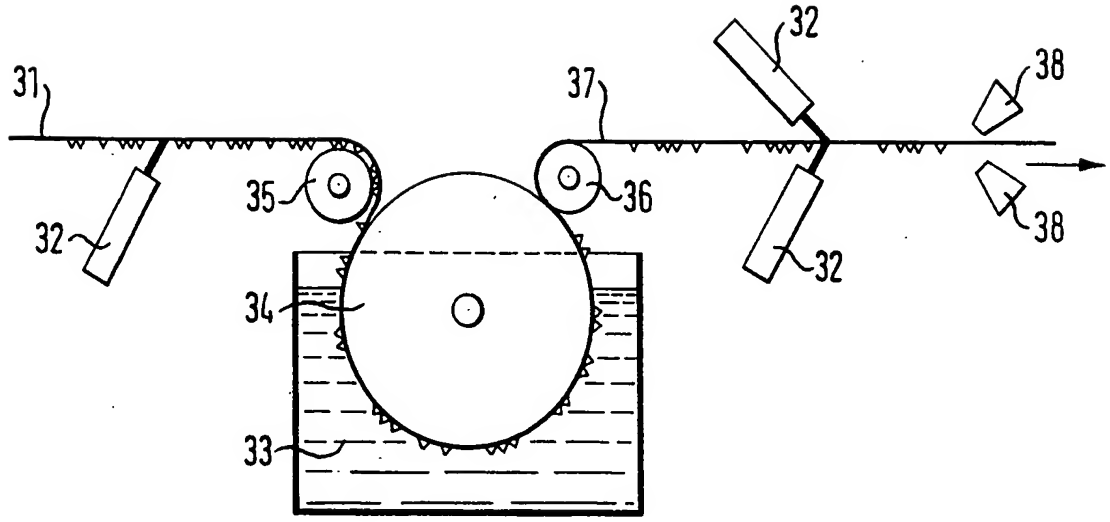


FIG. 4



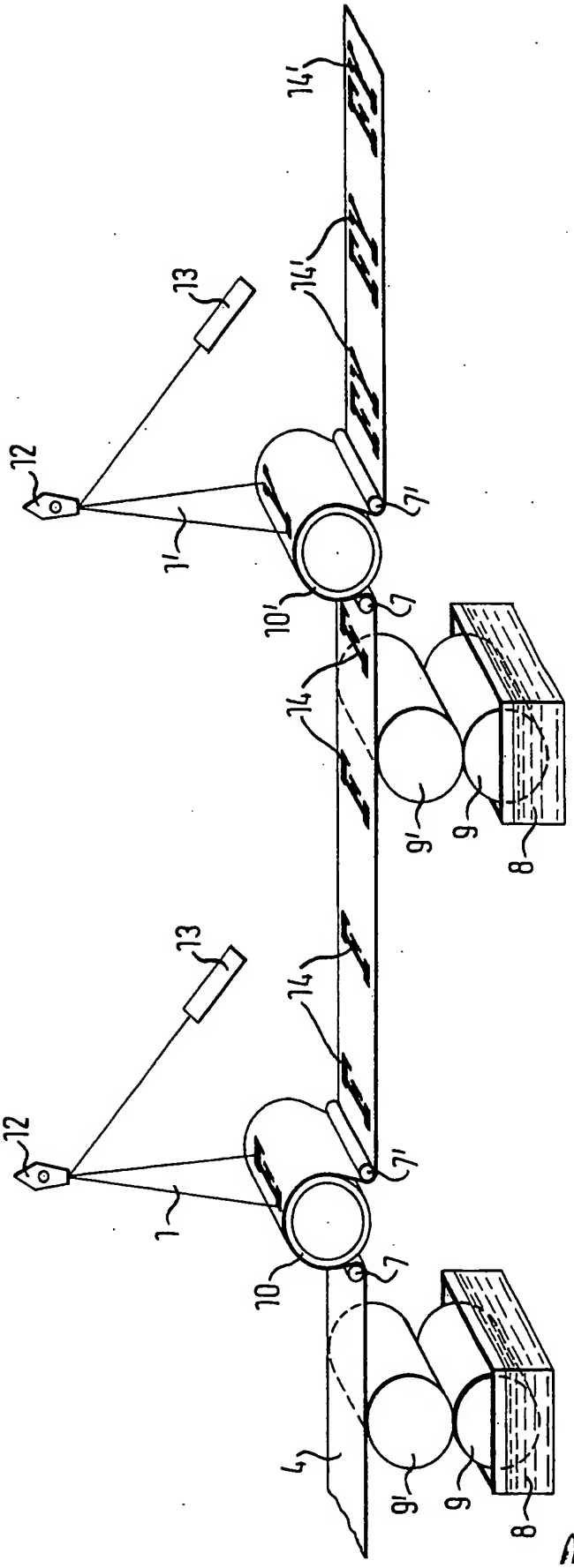



FIG. 5

FIG. 6

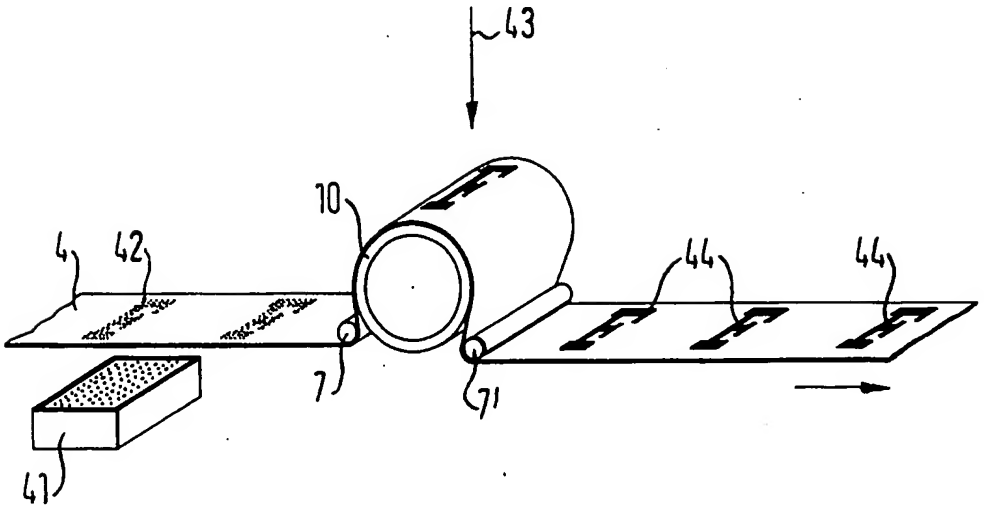



FIG. 7